(12) UK Patent Application (19) GB (11) 2 054 004 A

(21) Application No 8007917
(22) Date of filing 7 Mar 1980
(30) Priority data
(31) 79/08613
(32) 12 Mar 1979
(33) United Kingdom (GB)
(43) Application published 11 Feb 1981
(51) INT CL[3] E04B 1/80 F24J 3/02
(52) Domestic classification E1D 101 103 106 2022 364 404 405 413 422 424 523 F LES2 F4U 60
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(58) Field of search
E1J
E1R
E1W
F4U
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(54) **Reducing heat-transfer through opaque walls**

(57) An enclosure directly exposed to climatic conditions is bounded by wall(s) 1 at least a portion of whose area is opaque. At least a portion of wall 1 is faced on its exterior with a vitreous sheet 2 bearing a surface coating 3 which reflects infra-red radiation of wavelengths > 5 μm.

Coating 3 preferably faces outwards. Sheet 2 may be adhered to the wall 1 by a radiation-absorbing glue layer 6. Fluid circulation pipes 12 may be incorporated in the wall 1. A sheet 7 of glazing material preferably defines a space 5 closed from the external atmosphere. Alternatively, the sheet 2 may be held apart from the wall 1 to define such a space 5.

The coating may be doped SnO_2 or I_2O_3, e.g. 1100—20000 Å thick.

A reflective roller-blind 10, under the eaves, may be lowered to reduce I—R radiation to or from wall 1. A high thermal capacity or latent-heat energy store 14 may be present in a container 13. Wall 1 may be coated with a radiation-absorbing material.

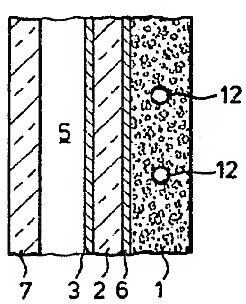

FIG. 4

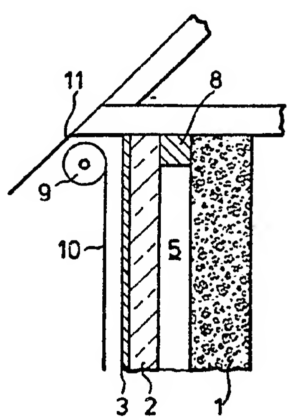

FIG. 5

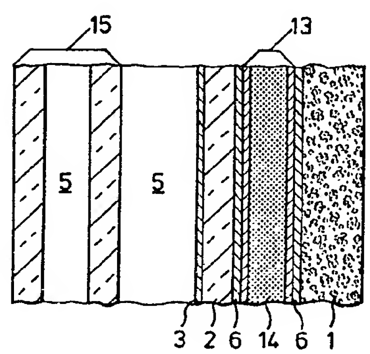

FIG. 6

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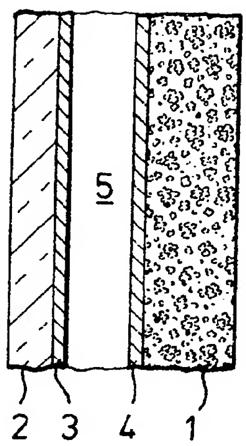

FIG. 1

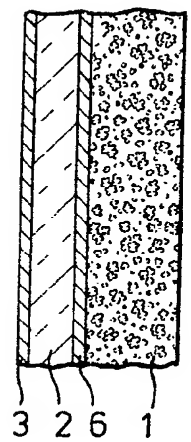

FIG. 2

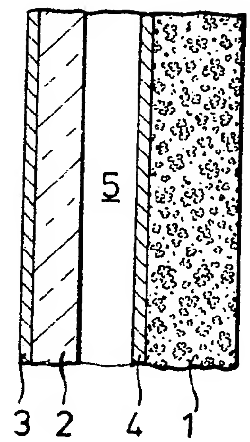

FIG. 3

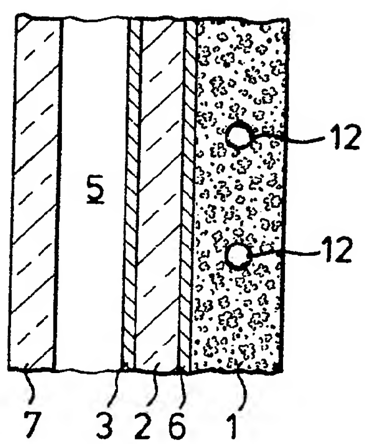

FIG. 4

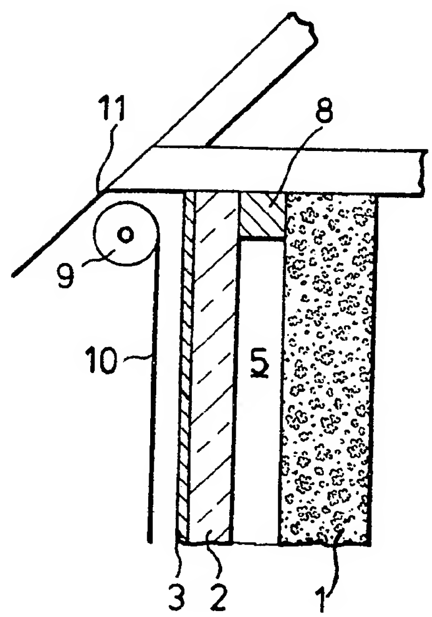

FIG. 5

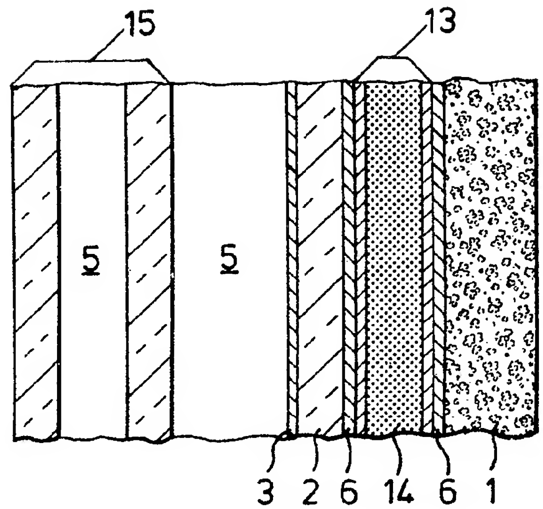

FIG.6

SPECIFICATION

Improvements in enclosures having opaque walls

This invention relates to an enclosure of a kind which in use is directly exposed to climatic conditions and is bounded by one or more walls at least a portion of the area of which is opaque to light radiation.

Such an enclosure may for example be constituted as a dwelling or workplace.

The invention is primarily concerned with heat loss from enclosures of the kind referred to. The insulation of modern houses by forming cavities in their external walls between two courses of brick or stone is of course well known, and it is also known to fill such cavities with foamed insulating material. But such a method of insulation must be allowed for at design stage of the buildings. It is not applicable in cases where the building was originally erected with no wall cavities.

The present invention aims to provide a novel way of providing insulation to an enclosure of the kind referred to which is quite independent of the construction of the walls.

According to the present invention, there is provided an enclosure of a kind which in use is directly exposed to climatic conditions and is bounded by one or more walls at least a portion of the area of which is opaque to light radiation characterised in that at least a portion of the opaque wall area is faced on its exterior with a vitreous sheet bearing a surface coating adapted to increase the reflectivity of the coated area in respect of infra-red radiation having wavelengths greater than 5 μm.

The invention affords the important advantage of reducing heat transfer from the thus faced wall area of the enclosure.

Considering an enclosure, heat loss from it can take place by radiation from the walls and by conduction through them combined with heating and convection of the atmosphere in contact with its exterior side. This latter mode, conduction and convection, varies substantially simply according to the temperature difference between the interior of the enclosure and the atmosphere which is in contact with the exterior of the walls, and also according to the wind speed. It has been found that the sky may for the purpose of radiation heat loss be considered as having an apparent temperature of between 5°C and 25°C lower than the temperature of the ambient atmosphere, depending upon weather conditions. Thus heat exchange by radiation between an enclosure at a given temperature and its environment, especially towards the sky, can reach quite significant amounts. By way of example, at a latitude of 51 degrees, energy loss by radiation towards the sky can be of the order of 150 watts/m^2 day and night. Under some conditions, such as when the air is very dry and the sky clear, the energy loss can reach 250 watts/m^2. In fact, in very approximate terms, 2/3 of the heat loss takes place by radiation, and the remainder by conduction and convection. By employing an infra-red reflecting coating on the vitreous facing for the opaque wall area or areas it is possible to reduce the radiation loss to a considerable degree. Merely by applying a coating to increase the infra-red radiation reflectivity of the light transmitting vitreous facing sheet, it is possible to arrive at a situation where only 1/3 of the total heat loss will take place by radiation.

The majority of the energy which would otherwise be radiated by the enclosure has a wavelength greater than 5 μm, and it is accordingly particularly valuable to select a coating which is effective at these wavelengths. Preferably, the reflectivity of the coating in that wavelength range is at least 0.5.

Preferably, said coating in on that surface of the sheet which is directed towards the exterior of the enclosure. In this way, of the incident energy absorbed by the coated sheet, more will be re-radiated towards the interior of the enclosure.

Preferably, such wall area is faced with two light transmitting sheets, either or both of which bears a said surface coating, the sheets being held in spaced facing relation to define an inter-sheet space which is substantially closed from the atmosphere which is external of the enclosure. This provides a body of air between the two sheets which can be warmed by incident solar radiation and thus act as a further heat loss reducing barrier for the enclosure.

Advantageously, said coating sheet is held in spaced relation from the wall to define a space which is substantially closed from the atmosphere which is external of the enclosure. This provides a body of air between the sheet and the wall which can also be warmed by incident solar radiation, and in general the air body will be warmer when it is located between the coated sheet and the wall than it would be when located between an uncoated sheet and the wall.

Indeed, the air in the space between the two sheets or between the coated sheet and the wall can be warmed to such an extent that it can usefully be used to augment a space heating system for the enclosure, and it is accordingly preferred that the space is in communication with a ventilation system for the enclosure.

Preferably, the or a said vitreous sheet is glued directly to the wall. This is a fairly inexpensive way of fixing that sheet in position.

Advantageously, such wall area is coated with a material which enhances its energy absorbing characteristics so that additional solar radiant energy is absorbed, and this in turn will augment heat absorption by enclosures of the kind referred to.

Preferably, said coating comprises a metal, a semiconductor or an oxide. Such coatings can be applied in known manner.

Advantageously, said coating comprises indium oxide and/or tin oxide. Tin oxide is especially preferred because it can form a hard, chemically and mechanically durable coating which allows it to be placed in direct contact with the atmosphere without taking any special precautions. Preferably, such an oxide coating is doped with ions of antimony, arsenic, cadmium, chlorine, fluorine and/or tellurium, since this will increase its efficacy.

Preferably, said coating has a thickness of less than 2 μm so as to allow visible light transmission. A said oxide coating preferably has a thickness of between 1200 Å and 12000 Å.

Advantageously, there is provided a screen, preferably a radiation reflecting screen, which is movable across such wall area. By making use of such a screen, for example at night, radiation heat loss can be further reduced. Furthermore, the screen can be used during the summer to protect the wall against absorbing too much solar radiation.

Preferred embodiments of the present invention will now be described in greater detail with reference to the accompanying diagrammatic drawings in which:

Figures 1 to 6 are detail cross-sectional views of various embodiments of the invention selected by way of example.

In Figure 1, there is shown an opaque wall 1, e.g. of stone, brick or concrete, which is faced with a glass sheet 2 which bears a coating 3 adapted preferentially to reflect infra-red radiation having wavelengths greater than 5 μm. The coating 3 is directed towards the wall 1 whose outer surface bears an optional coating 4 adapted to increase the radiation absorption characteristics of the wall. The glass sheet 2 is held apart from the wall 1 by suitable spacing means to define a space 5 which is substantially closed from the external atmosphere. The reflective coating 3 acts to reflect infra-red radiation emitted by the wall 1 so that the wall 1 and air space 5 remain warmer than they would in the absence of such a coating. If desired, the air space 5 may be in communication with a ventilation or hot air heating system for an enclosure of which the wall is illustrated.

Figure 2 illustrates an embodiment in which a glass sheet 2 bearing an infra-red reflecting coating 3 is glued directly to a wall 1 by means of a layer 6 of adhesive material. Of course in some cases there may be a direct bond between a suitable building material such as concrete and the glass sheet 2, so that the adhesive layer 6 is dispensed with. The coating 3 is directed away from the wall 1 to reduce the infra-red emissivity of the whole structure constituted by the wall 1 and glass facing sheet 2. The adhesive material of the layer 6 may be and preferably is of dark colour so as to increase the energy absorbing characteristics of the wall 1.

Figure 3 shows an embodiment which is similar to that shown in Figure 1 save that the infra-red reflecting coating 3 is located on that surface of the glass sheet 2 which is directed away from the wall 1. As compared with the Figure 1 embodiment, this embodiment has the advantage of also reducing the infra-red emissivity of the glass sheet 3 so that that sheet will remain warmer than in the arrangement of Figure 1. Again, an optional radiation absorbing layer 4 is shown, as is a substantially closed air space 5.

Figure 4 illustrates a modification to the embodiment of Figure 2. This modification consists simply in the addition of a second glass sheet 7 held apart from the first glass sheet 2 by suitable spacing means to define an air space 5 substantially closed from the atmosphere which is external of the enclosure. In a modification of this embodiment, there is a said reflecting coating such as a coating 3 on the inwardly directed face of the outwardly directed face of the second glass sheet 7. When such a coated second sheet is present, the coating 3 on the first sheet 2 may be omitted. In a modification of the embodiment shown in Figure 4, the glass sheet 7 is replaced by a double glazing panel. The air space 5 may be of any desired or convenient size and shape, and indeed it may be of such a size as to serve as a conservatory.

Figure 5 illustrates the upper part of a wall 1 of an enclosure to which a glass sheet 2 bearing an outwardly directed infra-red reflecting coating 3 is held in spaced relation by a mounting block 8. A holder 9 for a screen 10 or roller-blind type is mounted in the eaves beneath a roof 11 of the enclosure. The screen 10 is preferably adapted to reflect radiation, and may be opaque. Such a screen may be formed of woven fibres, whether natural or synthetic, for example cotton, glass, acrylic or methacrylic resin or polyester fibres or it may be of film material for example a film of a polyester, polyamide, polycarbonate, polyethylene, polyvinyl chloride or polypropylene. The screen is preferably metallised, e.g. aluminised so as to increase its reflectivity. The screen can be drawn down at night so as to further reduce the infra-red radiation emitted from the wall 1 of the enclosure, or indeed to prevent overheating on hot sunny days.

In a variant of the embodiment illustrated in Figure 5, a layer of radiation absorbing material (compare layer 4 of Figures 1 and 3) is applied to the outer surface of the wall 1. This layer may be constituted by a dark coloured paint.

In a further variant, a further glazing panel (not shown) is fixed to the wall 1 on the outerside of the screen 10. This further glazing panel may for example be a double glazing panel.

Figure 6 illustrates an embodiment in which a glass sheet 2 bearing an infra-red reflecting coating 3 is glued by an adhesive layer 6 to a container 13 fixed to the wall 1. The container 13 is filled with a material 14 which undergoes a reversible change of state accompanied by the evolution or absorption of heat energy at a predetermined temperature. The temperature may for example be in the range 15°C.

to 25°C. and the change of state involved may be a melting or a freezing of the material. In use, such material 14 tends to stabilise the temperature of the wall 1 against which its container 13 is mounted. For example as the container warms up during the day, the temperature stabilising material 14 will begin to melt, and the temperature of the wall 1 will not rise above the melting point of the temperature stabilising material 14 until that has all melted. Conversely at night, as the container cools, the temperature of the wall 1 will not sink below the freezing point of the temperature stabilising material 14 until that material has substantially completely frozen. In alternative embodiments, the container 13 is filled with a material of fairly high specific heat capacity, e.g. water so that it acts as a heat sink to slow down changes in the temperature of the wall 1.

An optional double glazing panel 15 is mounted spaced from the coated glass sheet 2 to provide, in effect, two air spaces such as the air spaces 5 of Figures 1, 3, 4 and 5.

In a modification of any of the illustrated embodiments, pipes 12 as shown in Figure 4 are provided for the circulation of fluid within the wall 1. Such pipes can allow transfer of heat from the wall 1 to fluid e.g. water flowing in the pipes 12, so as to give economies in a water heating system.

There now follow various examples of specific coatings 3 which may be applied to any of the glass sheets shown in the drawings.

	Coating material	Doping agent	Thickness	Visible light transmission	Infra-red reflectivity
I	SnO_2	Sb	4000Å	over 80%	0.7
II	SnO_2	F	3500Å	over 80%	0.75
III	SnO_2	Sb	1100Å	over 80%	0.5
IV	SnO_2	Sb	5000Å	over 80%	0.8+
V	In_2O_3	Cl	2000Å	85%	0.9

CLAIMS

1. An enclosure of a kind which in use is directly exposed to climatic conditions and is bounded by one or more walls at least a portion of the area of which is opaque to light radiation characterised in that at least a portion of the opaque wall area is faced on its exterior with a vitreous sheet bearing a surface coating adapted to increase the reflectivity of the coated area in respect of infra-red radiation having wavelengths greater than 5 μm.

2. An enclosure according to claim 1, characterised in that said coating is on that surface of the sheet directed towards the exterior of the enclosure.

3. An enclosure according to claim 1 or 2, characterised in that such wall area is faced with two light transmitting sheets either or both of which bears a said surface coating, the sheets being held in spaced facing relation to define an inter-sheet space which is substantially closed from the atmosphere which is external of the enclosure.

4. An enclosure according to any preceding claim, characterised in that said coated sheet is held in spaced relation from the wall to define a space which is substantially closed from the atmosphere which is external of the enclosure.

5. An enclosure according to claim 3 or 4, characterised in that the space is in communication with a ventilation system for the enclosure.

6. An enclosure according to any preceding claim, characterised in that the or a said vitreous sheet is glued directly to the wall.

7. An enclosure according to any preceding claim, characterised in that such wall area is coated with a material which enhances its energy absorbing characteristics.

8. An enclosure according to any preceding claim, characterised in that said coating comprises indium oxide and/or tin oxide.

9. An enclosure according to claim 8, characterised in that said coating is doped with ions of antimony, arsenic, cadmium, chlorine, fluorine and/or tellurium.

10. An enclosure according to any preceding claim, characterised in that said coating has a thickness of less than 2 μm.

11. An enclosure according to claim 8 or 9 and claim 10, characterised in that said coating has a thickness of between 1200 Å and 12000 Å.

12. An enclosure according to any preceding claim, characterised in that there is provided a screen which is movable across such wall area.

13. An enclosure according to claim 12, characterised in that said screen is a radiation reflecting screen.

14. An enclosure substantially as herein described with reference to any of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.